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Title:	**01. Bryan Nowack: Transforming the future of agriculture through basic research change.**
Episode:	**03**

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Bryan Nowack: So first of all, I have to say that basic research is very, very important and very great and should never be disregarded. Because only through basic research can we get to the application.

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Speaker announcement (under music): Listen.UP. The podcast of the University of Potsdam.

Speaker: Today: Making agriculture fit for the future through basic research. With Bryan Nowack.

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Bryan Nowack: And that's exactly why I applied for the Better World Award, because I said that although it's only basic research, basic research is also important and basic research can also change the world and make the world a better place. And on top of that, of course, the application is not that far away. Climate change is an important topic and the topic of the future. And we can see right now, the way politicians are acting and want to act, that we have to prepare for the fact that the 1.5 degree target will not be reached and that we have to prepare for the fact that the two degree target will not be reached. That is quite clear. That means that we have to adapt to the fact that our agriculture has to change. And that can mean that we grow other crops that are more heat-resistant. But it must also mean that we change our breeding and that we plant other varieties or breed new varieties of the plants we have.

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Speaker 2: Bryan Nowack is 24. Born and raised in Berlin, the model student knew very early on that he would study biology.
Speaker 1: And since he did so in Potsdam, he says, it is not surprising that he ended up with plants.

Bryan Nowack: At the beginning of my bachelor's degree, I actually wanted to go in the direction of immunology/virology, but Potsdam is such a large plant location - one of the largest in Germany - that you can't avoid being exposed to it somehow. And then I thought, well, I'll give it a try - plants. I did an internship with plants and I had so much fun with plants and found it so fascinating that I stuck with it. I wanted to do molecular biology and biochemistry anyway. That was clear and that's why I stayed in Potsdam and am now doing my doctorate there. Simply because if plants, then in Germany, definitely Potsdam.

Speaker 1: Bryan Nowack is currently working on his dissertation in Potsdam Golm. He also conducted research here for his Master's thesis, which was nominated for the "Better World Award". With the help

of fluorescent proteins, he tried to analyse how plants process heat stress and build up a "heat stress memory".
Speaker 2: What fascinates him most about plants is their incredible resilience.

Bryan Nowack: So plants simply have to be able to cope with everything, because they can only move very limitedly. So if an animal is thirsty, it goes to the watering hole. So, to put it simply a plant must not only recognise that it is thirsty, but it must also be able to react to it somehow without being able to move much. And that applies to all other stressors as well. That's what I find so exciting, as is the ability of plants to regenerate. Many people are familiar with this: you can cut off a leaf from a lot of plants, put the leaf in the soil and at some point the leaf itself will take root and you can produce a whole new plant from it.
In other words, a small component of the plant is able to produce a whole new plant. We hardly ever see this in mammals, for example. So if you cut off a finger, it won't come back. But it is possible with a plant and I find that incredibly exciting.

Speaker 1: Human-induced climate change, however, poses completely new challenges to the regenerative capacity of crops, which they are unable to meet with naturally acquired adaptation and survival strategies.
Speaker 2: Heat records like the one in Lytton, Canada, where the thermometers read 49.6 degrees Celsius in the summer of 2021, are a call to haste for the young researcher.

Bryan Nowack: I find that incredible. In the truest sense of the word. Simply because, such heat records, they are broken again and again, so that is not necessarily something special. But the way it's happening at the moment, at the speed we're seeing it now, it's unbelievable. And that's exactly why we need research like we're doing. Simply because we need to be able to react more quickly to the environment and, in this case, to climate change. In traditional breeding, it sometimes takes 10 to 12 years to achieve new cultivars with the desired characteristics. With new breeding methods such as genetic engineering or genetically assisted breeding, we are talking about two years. If we think about it, 12 years ago, climate change was a completely different issue and we simply need this speed to be able to secure ourselves and especially our food sources.

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Speaker 2: Bryan Nowack works with tissues and cells of the model plant *Arabidopsis thaliana*.
It is closely related to shepherd's purse, except that its pods are elongated rather than heart-shaped. It has very small, white flowers and a rosette of leaves close to the ground.

Speaker 1: In agriculture, it is considered a weed - and is found on all continents except the poles.

Bryan Nowack: And the reason why we use this as a model plant is the short generation time. It has only 5 chromosomes on which the genetic material is stored. That's super simple compared to some other plant species. And it is also only a double set of chromosomes, so just like in humans, where each chromosome exists twice, this is also the case in the Arabidopsis plant. But this is not the case with every plant, for example with normal bread wheat, which is hexaploid, that means 6 sets of chromosomes and there are even more chromosomes and they are also larger than in Arabidopsis. So we are talking about much, much, much more genetic material and that makes everything more complicated, because of course you have to go through the genetic material. Then there are genes that are duplicated, that support each other. Everything is simply more complex. And when you work with models, you always want to reduce the complexity. That's the other point, and otherwise Arabidopsis is a good choice because it's a weed, Arabidopsis grows whether you like it or not, more or less, and is very resistant to various stressors. So you can deal with Arabidopsis in a relatively simple way without running the risk of ruining everything straight away, like with orchids, for example.

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Speaker 1: In plant physiology, "stress" refers to environmental characteristics that counteract optimal growth. One speaks of heat stress when the temperature is so high that restricted growth, stopped growth or even the death of the plant is the result.
Speaker 2: *Arabidopsis thaliana,* for example, does not survive an hour at 44 degrees Celsius as a seedling.

Bryan Nowack: Arabidopsis can do maybe 15, if it's good, 25 minutes. But after that, it's over. The seedlings die and turn white and then nothing happens.

Bryan Nowack: What you can do instead of the 44 degrees heat stress for one hour, for example, is: you first give a lighter heat stress, for example 37 degrees for one hour, which Arabidopsis survives without major problems. And if you then give the strong heat stress 44 degrees directly afterwards, Arabidopsis suddenly survives the heat stress. So just that one hour of mild heat stress beforehand has ensured that the plant; the individual is suddenly adapted to an otherwise lethal heat stress that the plant would not have been able to cope with. That is simply an adaptation at first. The phenomenon we are now investigating in more detail is memory. That's a bit more bizarre. It's about giving the light heat stress, waiting several days and then giving the heavy heat stress. And you can still see that the plant survives better, that is, through this heat stress regime, which we gave on day 4, for example, the plant has been able to adapt or maintain the adaptation, until we see that partly up to day eight you can see it well. So four days approximately.

Speaker 2: This phenomenon is called "acquired thermotolerance". What is fascinating, says Bryan Nowack, is that the plant builds up a "molecular heat stress memory" without a brain or nerve cells.

Speaker 1: How this is done is being investigated in Potsdam Golm in the "Epigenetics of Plants" working group.

Bryan Nowack: A very interesting aspect here is that unlike animals, which makes plants more exciting again, there is no central nervous system. We don't have a central nervous system and we don't have central hormone glands like the thyroid gland, the pituitary gland, which can control many signals centrally. This means that of course there are plant hormones and of course there is communication between the cells, but all in all the cells have to react independently to a stress. So every cell must have the ability not only to recognise stress, but also to interpret it. And also to be able to react to it.
In other words, each cell is somehow left to its own devices. And what exactly happens there is a so-called epigenetic phenomenon.

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Speaker 1: Epigenetic phenomena are changes in the genetic material, but they do not take place on the basis of the actual DNA. Without touching the genetic code, the cell machinery makes changes, for example to the packaging of the DNA.

Bryan Nowack: So the DNA is packed very, very tightly in the chromosomes. Everyone has heard it once. If you were to unravel the DNA of a cell, it would be several metres long. That means the DNA has to be kept compact somehow. And the idea now is that if we pack the DNA very, very compactly, then the entire machinery, the cellular machinery, which would actually read out the DNA, can of course not get at it so well. Because it's packed very tightly and then you simply can't get at the information. But if the DNA is more loosely packed, then you can get much closer to it and read it out much more easily. It's a bit like putting a file on the desktop of your computer. Then, of course, you can get to it much faster when you need it again than if you pack it into 10 folders and subfolders, where it takes a while to find it. And such a phenomenon, we assume, also happens with heat stress memory, that is, the information is read, ok, I was in heat stress, which fortunately I survived. The computer didn't crash and what happened then is that the cell sort of takes the information that is important for surviving the heat stress out of all the subfolders of the PC and puts it temporarily on the desktop. In other words, instead of being tightly wound, the DNA is wound a little more loosely and packed a little more loosely so that in the future, if the heat stress comes again, it can be read immediately.

Speaker 2: In addition, there are markings that indicate where the DNA is more loosely wound.

Bryan Nowack: And it's not just the packaging itself, there are quite a few different markings. Some that we don't even understand yet or maybe haven't even found yet. They could act a bit like signal flags that say "OK, there used to be something here". And when something comes again, the machinery recognises it more quickly.

Speaker 1: Bryan Nowack's master's thesis is entitled:
Speaker 2: “Increasing the resolution of heat shock response analysis in roots through the use of fluorescent proteins”.
Speaker 1: In it, he is trying to establish a new method to perform heat stress analysis in individual cells and tissues.
Speaker 2: In particular, the question is how stress memory is stored in the roots and whether this is a digital or analogue phenomenon.

Bryan Nowack: Analogue means that if zero is off and one is on, then there are theoretically an infinite number of intermediate stages. So it's like a regulator. I can go from 0 to no heat stress response to 1 full blast. And then there are an infinite number of intermediate stages. A digital is either 0 or 1, like a computer. Zeros and ones. There are no intermediate levels - either it's on or it's not on.

Speaker 2: All questions that may sound like quibbles to the layman but are highly relevant to agro-industrial research and breeding when it comes to developing heat-resistant varieties.

Bryan Nowack: And the goal is, with my research and our research, that we put the targets in the hands of the breeders. We can say ok, these genes are important. These places on the chromosome, they are important. We may not always know exactly why, but they are important. And then the breeder can say okay. Then I'll give it a try. And then I switch off this place, then I switch off the gene, I switch on the gene, ideally in my opinion with genetic engineering. That is the future. That has to be the future. Even if Europe and many Germans don't want to admit it. But genetic engineering is not the devil we paint on the wall these days.

Speaker 1: But isn't the attitude towards genetic engineering in agriculture changing right now?

Bryan Nowack: Slowly, too slowly. We have now seen this again in the EU, where all kinds of scientific associations - Leopoldina, Max Planck Society - cried out at the ECJ ruling that CRISPR/CAS continues to be treated extremely restrictively.

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Speaker 2: CRISPR/Cas, which is a so-called "gene scissor".
Speaker 1: In other words, a molecular biological method with which DNA can be specifically cut and modified.

Bryan Nowack: It's a system that allows you to make targeted changes in the genome. And the great thing is that you can really do it in a very targeted way. And the problem is that CRISPR CAS and also other similar gene scissors that existed before are treated extremely restrictively. Because the EU thinks that the goal is irrelevant, so the method is banned.

Speaker 2: In July 2018, the European Court of Justice decided not to approve any plants modified with the CRISPR/Cas method - even if no foreign DNA was inserted into the plant's genome, but only individual genes were removed or switched off.
Speaker 1: Which can also happen at any time under natural conditions and with traditional breeding methods.

Bryan Nowack: And the absurd thing is that we approve of traditional breeding methods, which are not treated so restrictively, which are the exception. Although theoretically they could be much worse. What we do in traditional breeding is we use chemicals, radioactive radiation or X-rays. We take our seeds. We fry them full of chemicals, radioactive radiation, make thousands of changes all over the genome. Random changes that don't cause the peppers to become radioactive or anything. They simply cause changes in the genetic material, which is not bad in itself...

Speaker 2: By the way, mutagenesis by means of radioactive radiation, X-rays or chemicals such as EMS is also permitted in organic farming.

Bryan Nowack: And what the breeder does is, he just looks at thousands of seeds, looks at okay, where is the pepper particularly large? Where is the pepper particularly red and tasty? And maybe, maybe at some point you know okay, it was these two genes in this pepper line that worked. But the thing is that in the background there are still hundreds, thousands of other changes.

Speaker 1: It is, as the biochemist Holger Puchta put it in a Spiegel interview, as if one were to "ban the scalpel but allow the shotgun".

Bryan Nowack: And that's why I like to be so active in science communication, because people tell me "genetic engineering is bad, because man shouldn't play God." And then I think to myself, we have been breeding grain in an unnatural way for 10,000 years - the wheat we have today would never have arisen naturally. People have deliberately cross-bred to produce it. Isn't that also playing God? Why is the CRISPR gene scissors so much worse and playing God? But frying with X-rays and then seeing what comes out is okay. That makes no sense.

Bryan Nowack: You just have to find the mix and you have to question the meaningfulness of everything. And especially you have to pay attention to the goal and to the end product and not always to the path if the end product is the same. Then it doesn't matter. In most cases, no matter how I got there. As long as it's ethical, of course, how I got to the goal. And that is missing. And there is also a lack of education in society.

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Speaker Closing Remarks: Listen.UP-The Podcast of the University of Potsdam.

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